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GUIDANCE FOR ENVIRONMENTAL TESTING

PART X MOULD GROWTH TEST

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GUIDANCE FOR ENVIRONMENTAL TESTING
PART X MOULD GROWTH TEST

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GUIDANCE FOR ENVIRONMENTAL TESTING

PART X MOULD GROWTH TEST

0. FOREWORD

0.1 This Indian Standard (Part X) was adopted by the Indian Standards Institution on 10 October 1975, after the draft finalized by the Environmental Testing Procedures Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This standard has been largely based on IEC Publication 68-2-10A (1969) 'First supplement to Publication 68-2-10 (1968) Basic environmental testing procedures, Part 2: Tests — Test J: Mould growth' issued by International Electrotechnical Commission.

0.3 This standard (Part X) should be read in conjunction with IS : 9000 (Part X)-1979*.

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960†. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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1. SCOPE

1.1 This standard (Part X) deals with the guidance on details of the test for mould growth on equipment and components (both electronic and electrical).

2. MECHANISMS OF CONTAMINATION

2.1 Fungi grow in soil and in, or on, many types of common materials. They propagate by producing spores which become detached from the main growth and later germinate to produce further growth.

2.2 These spores are very small and readily carried in moving air. They also adhere to dust particles and enter with them into equipment.

*Basic environmental testing procedures for electronic and electrical items : Part X Mould growth test.

†Rules for rounding off numerical values (*revised*).

2.3 All parts of an equipment to which air may penetrate may thus be contaminated with mould spores carried in that air.

2.4 Contamination may also occur due to handling. Spores may be deposited by the hands or in the film of moisture left by the hands.

2.5 Contamination may in addition be caused by mites, capable of penetrating into very small gaps (down to 25 μ) and carrying mould spores on their bodies. The bodies and excreta of the mites collect and may provide a film of nutrient and moisture which may favour the propagation of mould from the spores.

3. GERMINATION AND GROWTH

3.1 Moisture is essential to allow the spores to germinate and where a layer of dust or other hydrophilic material is present on the surface, sufficient moisture may be abstracted by it from the atmosphere.

3.2 When the relative humidity is below 65 percent, no germination or growth will occur. Growth will be more rapid the higher the humidity above this value. Spores may, however, survive prolonged periods of very low humidity and even though the main growth has died, they will germinate and start a new growth as soon as the humidity again becomes favourable.

3.3 In addition to high humidity in the atmosphere, the spores require that there shall be on the surface of the item a layer of material which absorbs moisture. Provided this damp layer is present, most organic materials will supply sufficient nutrient to support at least a little growth. When dust is present, this contains ample nutrient for the purpose. Mould growth is encouraged by stagnant air spaces and lack of ventilation.

3.4 The optimum temperature of germination for the majority of moulds likely to give trouble in equipment lies between 20°C and 30°C. Rare types may however, germinate below 0°C and some as high as 40°C.

3.5 Many spores are not damaged by prolonged exposure to subzero temperatures, nor by exposure to high temperatures up to 80°C.

3.6 To kill spores by heat treatment, it is necessary to expose them for at least 30 minutes to a moisture saturated atmosphere at 120°C (autoclave) or for 2 to 3 hours in a dry atmosphere at 140 to 180°C.

4. EFFECTS OF GROWTH

4.1 Primary Effects

4.1.1 Moulds live on most organic materials, but some of these materials are much more susceptible to attack than others. Growth normally occurs only on surfaces exposed to the air, and those which absorb or adsorb moisture will generally be more susceptible to attack.

4.1.2 Even where only a little direct harmful attack on a material occurs, the formation of an electrically conducting path across the surface due to a layer of wet mycelium may drastically lower the insulation resistance between electrical conductors supported by an insulating material.

4.1.3 When the wet mycelium grows in a position where it is within the electromagnetic field of a critically adjusted electronic circuit, it may cause a serious variation in the frequency-impedance characteristics of the circuit.

4.1.4 Among the materials very susceptible to attack are leather, wood, textiles, cellulose, silk and other natural materials. Most plastic materials are less susceptible, but are also attacked. Where a synthetic resin is not itself appreciably attacked but contains a plasticizer, organic filler, or pigment, which is a nutrient for fungi, a copious growth may occur on the surface where this secondary material is exposed.

4.1.5 Mould attack on materials usually results in a decrease of mechanical strength and change in other physical properties. Because this attack is always on the exposed surfaces, the seriousness of the effect will depend upon their geometric shape. A film, for example would be rapidly destroyed while the life of a thick section would not be noticeably diminished.

4.1.6 Some plastic materials depend for their satisfactory life on the presence of a small proportion of plasticizer. This plasticizer may migrate and if it is readily digested by fungi as soon as it migrates to the surface, the main material may fail rapidly due to continuous migration and extraction of the plasticizer.

4.2 Secondary Effects

4.2.1 The growing mould on the surface of a material may yield acid products and other ionized substances which will cause a secondary attack on the material. This attack may lead to electrolytic or ageing effects, and even glass may lose its transparency due to this mechanism. Oxidation or decomposition may be facilitated by the presence of catalysts secreted by the mould.

4.2.2 The presence of a mass of mycelium may provide a saturated sponge which will maintain a high humidity within an item even when the humidity has fallen to a low level outside it. This leads to failure of components due to humidity alone.

4.2.3 The presence of mould growth will be aesthetically distasteful due both to poor appearance and to the aroma which frequently accompanies the mould.

4.3 Effects Associated with Equipment — Due to the modular design and inter-connection of much modern equipment, mould growth in one

area of an equipment may have quite severe effects in another sub-unit or module which in itself may not permit the growth of mould. The possible effects on the performance as a whole shall, therefore, be asessed when considering primary or secondary effects on individual sub-units or components.

4.3.1 It should also be remembered that some equipment may contain components and/or sub-assemblies which, for various reasons, may not have been designed to be resistant to mould growth, and the overall performance of the equipment may be affected by the limited resistance of these items.

5. PREVENTION OF MOULD GROWTH

5.0 The following procedures have been used with varying degrees of success in combating the harmful effects of mould growth:

a) Complete sealing of the equipment/component with a dry clean atmosphere within is the most effective technique for preventing mould growth.

b) Continuous harming within an enclosure will ensure a sufficiently low humidity to avoid mould growth.

c) Operation of an equipment/component within a suitably controlled atmosphere (air-conditioned room) may prevent harmful growth of fungi.

d) Regularly replaced dessicants within a partially sealed enclosure will maintain a humidity sufficiently low to prevent harmful growth of fungi.

e) Periodic and careful cleaning of an enclosed equipment, removing most of and accumulated growth and dust (nutritive layer), will hold deterioration in check.

f) Fungicides, carried, for example, in varnishes, included in tablets, or sprayed directly, will prevent mould growth for a time (*see* **8** for guidance on fungicides).

g) Ultra-violet radiation of sufficiently high intensity will prevent mould growth and also kill existing mould growth. In practice, it is difficult, because of shadows and other problems, to sterilize equipment effectively by means of ultra-violet radiation.

h) Ozone at adequate concentration may, under suitable circumstances, kill existing mould growth. For example, ozone concentration in the vicinity of corona discharges or high-voltage discharge lamps may be high enough for the purpose.

j) Natural air circulation tends to deposit dust to a much greater extent than forced circulation and consideration shall be given to

the areas in an equipment in which dust is likely to be deposited. It should also be noted that air currents of adequate velocity flowing over the parts will retard the development of mould growth.

k) Pesticides may be used to control the action of mites.

5.1 All insulating materials used should be chosen to have as great a resistance to mould growth as possible, thus maximizing the time taken for mycelium to grow, and minimizing any damage to the material consequent upon such growth.

5.2 The use of lubricants during assembly, varnishing finishing, etc, should be avoided wherever practicable. Even if it is shown that the lubricants do not support mould growth, they may attract and collect dust which in turn will support mould growth. However the use of products containing fungicides is often recommended for the protection of some materials.

5.3 Moisture traps which may be formed during the assembly of an equipment and in which mould's grow shall be avoided. Examples of such less obvious traps are — between unsealed mating plugs and sockets or between printed circuit cards and edge connectors in particular attitudes.

6. APPLICABILITY OF THE MOULD GROWTH TEST

6.1 Mould growth testing of an equipment should normally be limited to verifying, where necessary, that suitable components and materials have been used, as any mould growth tests involving the complete equipment will often be prohibitively expensive or may yield results of rather doubtful value. Most of the required information may usually be more readily and accurately obtained from tests on materials, sub-assemblies, small composite sections, components, parts, etc.

6.2 The testing of materials for resistance to mould growth is a specialized technique, requiring both mycological knowledge and access to a wide collection of cultures. Such testing shall, therefore, be performed by a station specially equipped for the work, and the manufacturer should choose his constructional materials on the basis of test reports issued by such an authority.

6.3 The mould growth test is intended as an overall check that where a wise choice of previously tested materials has been made at the design stage, any mould growth which will occur under very adverse conditions will not have too serious an effect on the item.

6.4 This test is not a substitute for a proper choice of materials, and it is impossible to devise a simple test which replaces careful pretesting of materials and expert assessment of the results.

6.5 The wise choice of previously tested materials is the most important single precaution to take when designing items to operate in humid

environment. Where severe contamination of the insulating surfaces will not occur, such a choice is often the only precaution which needs to be taken and will prove adequate for all but the most severe conditions. Where the item operates under conditions which favour mould growth for only a small proportion of the total life, or where some measure of protection is given, as, for example, enclosing and heating continuously to reduce internal humidity, there should be no necessity to employ the mould growth test provided materials have been correctly chosen and good constructional principles have been employed. If such principles have not been employed, test for mould growth is not adequate to find all possible sources of trouble.

6.6 Mould growth test, as a final overall check on well-designed items intended to operate under conditions strongly favouring mould growth, employs only a small selection of cultures chosen to attack those materials used in industry which are fairly resistant to mould growth. It will indicate, therefore, the nature of any trouble to be encountered on well-designed items. On items with bad design and unsuitable materials, this test will not locate all the faults which may be encountered in service, because the testing procedure has been simplified to make it practicable for performance in an environmental test laboratory.

6.7 Three basic types of effect are catered for in this test:

a) *Extent of growth and attack on the surface after 28 days exposure* — This is probably the form of test which will be of most frequent use. The extent of growth checks whether resistant materials have been used. The location of growth will indicate areas in which trouble may be expected, and where greatest clearances or creepage distances should have been allowed. Attack on the surface will indicate locations where physical damage is likely to result from mould growth.

b) *Effect on performance while still damp after 84 days exposure* — This test gives an indication of the order and nature of performance variation to be expected where items operate under conditions in which mould is growing. The presence of humidity will itself result in variation of performance and it is essential to perform two sets of measurements, one on items without fungus infection and the other with fungus infection. The difference between the two will be the effect of the presence of wet mycelium.

   Accurate assessment of the difference may be difficult, since on samples without fungus infection mould may grow spontaneously because the fresh air also contains mould spores. To prevent spontaneous mould growth, particular precautions are necessary.

c) *Effect on performance after recovery of 24 hours following 84 days exposure* — This gives an indication of the order and nature of

performance variation due to the presence of mycelium which has grown during a period of non-operation and is present at low humidity. This provides for items which are stored in conditions where mould growth will be profuse but which are later installed and operated in an air-conditioned room. For this also, two series of measurements are necessary to discriminate between permanent effects due to humidity exposure, and those due to the presence of mycelium.

6.8 Under special conditions or where equipment is very expensive, it may be decided when writing a specification to vary the standard procedures of the test for mould growth. This is, of course, always possible at the discretion of the user, but in the opinion of those devising this routine any amelioration of this procedure would render the test uneconomical, although it might reduce the immediate cost. This is an expensive test procedure and should only be employed when the information is essential. To reduce the conditions would make the results so meaningless that it would be better to omit the test altogether where he cost of the full procedure is not justified.

6.9 Finally it should be remembered that, in the natural environment, mould spores are usually wind-borne whilst for test purposes it is necessary to introduce them in an aqueous suspension and spraying is used to introduce the aqueous suspension. Particularly in the case of equipment, the method and degree of penetration may, therefore, be totally different.

7. DANGER TO PERSONNEL

7.1 The moulds specified for this test are not normally considered a serious hazard for human handling.

7.2 It is possible for an individual to be allergic to one of them and, for this reason, it is wise to exercise care when performing the test. Surgical gloves may be worn to protect the hands, and care should be taken not to splash the suspension on other areas of the skin or on clothes.

7.3 It is also possible, during the incubation period in the test chamber for a foreign mould, present as an unintentional intruder, to develop; some of these moulds, thus present as native to some testing locations, may be injurious to the human system. For this reason there is a possibillity that the items after exposure may be a hazard and they should be handled with care.

7.4 The greatest danger, if some hazardous foreign mould is present on exposed items, is that small, dry, detached particles may become air-borne and be carried into the lungs. This is only likely to happen after the item has dried out; if it is carried quickly from the test chamber to a normal chemical fume-cupboard before it has time to dry, the flow of air does not reach the aperator and detached fragments will not enter the nasal passages.

7.5 Detached portions of growth may be so small that no protection is offered by wearing a gauze mask, and only a special respirator for sub-micron particles is effective. The use of a fume-cupboard as suggested in **7.4**, however, is considered an adequate precaution when performing this test.

7.6 Where the test location may contain such a harmful mould, vestiges of it may well remain in the test chamber and present a similar danger when it is being cleansed. The preferred cleansing treatment with high temperature steam will render the chamber completely harmless. Where, however, fumigation with propylene oxide is adopted, it will be noted that the test calls for fumigation prior to washing; this will ensure that all residues washed from the chamber are completely harmless.

7.7 When it is desired to preserve an item for future reference, it too should be fumigated with propylene oxide or sterilized in steam.

8. USE OF FUNGICIDES

8.0 A technique often used to give equipment an additional resistance to harmful mould growth is to use a suitable fungicidal material to inhibit or prevent the growth of fungi.

8.1 Application — Four different methods have been widely used for applying fungicides.

8.1.1 Incorporation into an organic resin during manufacture or processing. A typical example of this practice is the inclusion of such a material in the formulation of flexible PVC compounds.

8.1.2 Impregnation of a susceptible material with a fungicide during fabrication. A typical example of this is treatment of cellulose threads during the spinning process.

8.1.3 Inclusion of fungicidal material in a lacquer which is later used to spray the interior surfaces of an equipment.

8.1.3.1 When a fungicide has been incorporated in a lacquer and used for spraying an equipment, it is essential that the lacquer itself shall not encourage fungus growth because after a prolonged period the major portion of the fungicide will have evaporated out of it.

8.1.4 Placing of a tablet of fungicidal material inside an enclosure. Such tablets are often enclosed within sensitive indicating instruments.

8.2 Limitation of Use — When choosing a fungicide which will be enclosed in equipment, certain principles shall be borne in mind. The most important are given in **8.2.1** to **8.2.3**

8.2.1 The fungicide shall not give rise to a toxic atmosphere which would harm personnel opening up the equipment to service it.

8.2.2 The volatile products of the fungicide shall not lead to deterioration of component parts of the equipment, such as poisoning of selenium rectifiers by mercury compounds, electrolytic corrosion of metallic parts, lowering of insulation resistance or breakdown voltage over the surface of insulators, formation or deposition of an insulating film on the contacts of relays, switches, etc.

8.2.3 Where light-sensitive components, such as photo-cells are included in the equipment, the volatile products of fungicide shall not give light-absorbing layers on the windows of the component.

8.3 Permanence of Fungicidal Action — While a fungicide shall be sufficiently volatile to allow a suitable concentration to be maintained wherever mould growth might give rise to harmful effects, the following points shall also be borne in mind.

8.3.1 It should be stable and durable at the highest temperature likely to be experienced inside the equipment.

8.3.2 It shall resist leaching by repeated condensation of moisture over the internal surfaces.

8.3.3 It shall not be so volatile that it will be completely expanded in a few months.

8.3.4 To check the permanence of the fungicide, it may be necessary to carry out tests at high temperature, at high humidity and, possibly, under solar radiation, before making the mould growth test. Where such a programme is considered necessary it should be stated in the relevant specification.

8.4 Purpose

8.4.1 A fungicide may be chosen to give either extreme protection for a few months during transit through humid environments or a moderate protection over a prolonged period. When it is used to give short period protection during transit, test for mould growth should be performed with the active fungicide in place.

8.4.2 Even when a fungicide is intended to give prolonged protection, normal evolutionary variation tends to select a variant of the mould which is resistant to the fungicide used. It is desirable, therefore, when perpetual protection is required, that not only should the fungicide be renewed periodically, but that it should be replaced by fungicide of a different type.

8.4.3 Where a fungicidal varnish is used, and where the equipment may be required to continue functioning after the fungicide has lost its effectiveness, test for mould growth should be performed on an equipment sprayed with a varnish identical in composition except that it contains no fungicide.

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